1. INTERNATIONAL PERFORMANCE MEASUREMENT & VERIFICATION PROTOCOL (IPMVP)

The IPMVP is a document which discusses procedures that, when implemented, allow building owners, energy service companies (ESCOs), and financiers of building energy efficiency projects to quantify energy conservation measure (ECM) performance and energy savings. The procedures also provide for measurement and verification of ECM performance over time to ensure predicted savings are maintained. The IPMVP provides an overview of current best practice techniques available for verifying savings from both traditionally- and third-party-financed energy and water efficiency projects.

A. Purpose:

The purpose of the IPMVP is to:

- Increase certainty, reliability, and level of savings;
- Reduce transaction costs by providing an international, industry consensus approach and methodologies;
- Reduce financing costs by providing project measurement and verification (M&V) standardization, thereby allowing project bundling and pooled project financing;
- Provide a basis for demonstrating emission reduction and delivering enhanced environmental quality;
- Provide a basis for negotiating the contractual terms to ensure that an energy efficiency project achieves or exceeds its goals of saving money and improving energy efficiency.

B. Measurement and Verification Options:

Each of the four M&V options defined in the IPMVP is applicable to different types of performance contracts, project values, and risk sharing between the energy service company (ESCO) and the owner. The purpose of defining several M&V options is to allow for variations in the cost and methods for assessing savings. Consequently, the M&V options described within the IPMVP vary in accuracy, cost of implementation, strengths, and limitations.

M&V Option	How Savings Are Calculated	Cost
Option A: Focuses on physical assessment of equipment changes to ensure the installation is to specification. Key performance factors (e.g., lighting wattage or chiller efficiency) are determined with spot or short-term measurements and operational factors (e.g. lighting operating hours or cooling ton-hours) are stipulated based on analysis of historical data or spot/short-term measurements. Performance factors and proper operation are measured or checked annually	Engineering calculations using spot or short-term measurements, computer simulations, and/or historical data	Dependent on number of measurement points. Approximately 1-5% of project construction cost of items subject to M&V.
Option B: Savings determined after project completion by short-term or continuous measurements taken throughout the term of the contract at the device or system level. Performance and operations factors are monitored.	Engineering calculations using metered data	Dependent on number and type of systems measured and the term of analysis/ metering. Typically 3-10% of project construction cost of items subject to M&V.
Option C: After project completion, savings determined at the "whole-building" or facility level using current year and historical utility meter (gas or electricity) or sub-meter data.	Analysis of utility meter (or sub-meter) data using techniques from simple comparison to multivariate (hourly or monthly) regression analysis.	Dependent on number and complexity of parameters in analysis. Typically 1-10% of project construction cost of items subject to M&V.
Option D: Savings determined through simulation of facility components and/or the whole facility	Calibrated energy simulation/modeling; calibrated with hourly or monthly utility billing data and/or end-use metering	Dependent on number and complexity of systems evaluated. Typically 3-10% of project construction cost of items subject to M&V.

C. Generic Monitoring and Verification Steps

M&V Basic Steps – All Methods. M&V of new buildings differs fundamentally from retrofit projects in that performance baselines are hypothetical rather than actual, and are therefore generally not physically measurable or verifiable. The implications of this increase with the complexity of measures and strategies to be monitored and verified. Yet the basic steps in new building M&V do not vary significantly in concept from retrofit M&V. These steps are as follows:

1. Define Baseline. Definition of baseline is actually a two-part process. First, a design baseline must be developed and defined. This can range from the stipulation of specific baseline equipment to specifying whole-building compliance with energy codes or standards. Once the design baseline has been established, computer-aided analytical tools are used to estimate the associated energy performance baseline.

2. Define Energy Efficient Design and Projected Savings. The energy efficient design is defined through the building design process, and is the natural outcome of that process. Computer-aided tools (such as DOE-2) are then used to estimate performance of the energy efficient design, which is subtracted from the baseline energy performance to generate projected savings. The estimation process should also include the identification and, if possible, quantification of factors that could affect the performance of both the baseline and energy efficient design.

3. Define General M&V Approach. Section 6.2.2 of the IPMVP presents new building M&V methods that are roughly analogous to the M&V retrofit Options A, B, and C presented in Section 3.10 of the IPMVP and reproduced above. The A and B analogs are directed at end-use measures, and C addresses whole-building M&V methods. The relative suitability of each approach is a function of the following:

   - The M&V objectives and the requirements of nay related performance contracts.
   - The number of ECMs and the degree of interaction with each other as well as with other systems.
   - The technical practicality and issues associated with M&V of particular ECMs or broader whole-building ECMs and strategies.
   - Current trends toward more integrated and holistic new building design that are moving M&V requirements more to the Option C end of the Option A-B-C spectrum.

4. Prepare Project-Specific M&V Plan. Development of an effective and efficient M&V plan for new buildings tends to be more involved than retrofit projects since performance strategies are usually more complex and the technical issues more challenging. Development of an M&V plan should begin during the early design phases of the project for the following reasons:
   - Technical analyses that are performed in support of design decisions concerning energy performance during the building design process provide a starting point in defining the M&V objectives and approach. The key elements of energy analysis are also usually key factors in M&V. Therefore, the energy analyses and projections should be well documented and organized with this in mind.
   - M&V considerations can, and should affect certain design decisions such as instrumentation, building system organization, etc.

5. Verify Installation and Commissioning of ECMs or Energy Efficient Strategies. Installation and proper operation is verified through site inspections as necessary combined with review of commissioning reports, fluid balancing reports, etc. Any deviations should be noted and addressed through adjustment of the affected performance projections.

6. Determine Savings Under Actual Post-Installation Conditions. Virtually all energy performance projections are predicated upon certain assumptions regarding operational conditions, e.g.,

occupancy, weather, etc. This affects both the baseline and energy efficient design estimations. Deviations from the operational assumptions must be tracked by an appropriate mechanism (site survey, short and/or long term metering, etc.) and the baseline and energy efficient projections modified accordingly to determine actual savings.

7. Re-evaluate at Appropriate Intervals. Ongoing performance of ECMs or energy efficient strategies and the associated energy savings must be re-evaluated and verified at intervals and over a time frame appropriate to M&V and related performance contract requirements. This also allows ongoing management and correction of significant deviations form projected performance.

D. Summary of IPMVP Option B for New Buildings:

To use IPMVP Option B for new buildings, parties typically stipulate baseline energy consumption using a computer software energy simulation tool such as DOE-2.1. Projected energy savings are then developed based on proposed energy conservation measures and design strategies incorporated into the simulation tool analysis. After the building is built and occupied for a specified period of time, energy savings projections are adjusted by calibrating the simulation tool analysis to actual operating conditions using data from metered energy conservation measures.

Energy efficiency measures chosen to be metered can be any factor that materially affects the generation of savings. Operating hours and power draw over a period are typical examples of measured variables. Increased metering complexity produces higher verification accuracy at the expense of measurement and verification (M & V) cost. Using statistical sampling of similar multiple end-use points (such as motors or lamps) may be more appropriate for simple systems. Use of short- or long-term metering data typically depends on the constancy and/or predictability of the load. Another valuable aspect of metering to consider is that that metering provides long-term persistence operation data that can be used to improve or optimize the operation of equipment on a real-time basis.* (see note below)

E. Basic Steps to Implementing the IPMVP Option B:
In addition to the information provided above under the generic monitoring steps, the following apply specifically to IPMVP Option B:

1. Define baseline and estimate energy performance. For LEED purposes, this is a building complying with ASHRAE/IESNA Standard 90.1-1999 or the local code, whichever is stricter.
2. Define energy efficient design (energy conservation measures (ECMs)) and calculate initial savings estimate. This is a comparison of energy performance of baseline building and energy efficient building using the estimating tool/software.
3. Define general measurement and verification approach (data collection plan) during early project design phases. LEED specifies use of Option B for new buildings. (See IPMVP Chapter 6).
4. Verify installation and commissioning of ECMs.
5. Determine savings under actual post-installation conditions. Initial savings estimates are modified to account for as-built verified conditions and calibrated with monitoring data of operating conditions.
6. Re-evaluate at appropriate intervals. Typically performed annually after the first year of operation.

* By using metering data to commission and optimize the performance of building systems, the City of San Diego's 73,000 square foot Ridgehaven office building has been able to reduce its kWh per square foot load from an already phenomenal 9 kWh at initial occupancy in 1996 to an amazing 6.5 kWh in 1999, saving the City over $80,000 per year in energy costs.

F. Additional Notes on Successful Specification and Use of the IPMVP:

Successful use of the IPMVP and the specification of a M & V method (e.g. IPMVP Option B) requires at least the following:

- State the document to be referenced, e.g. the IPMVP.
- State which option and method from the document will be used, e.g., Option B with post-installation metering of operating hours.
- Indicate who will conduct the M & V.
- Define the details of how calculations will be made.
- Specify metering to be conducted including information on the equipment, calibration, location of measurements, metering period, etc.
- Define key assumptions to be made about significant variables or unknowns.
- Define the level of accuracy to be achieved, if not for the entire analysis, at least for key components;
- Indicate how quality assurance will be maintained and repeatability confirmed.
- Indicate reports to be prepared, their contents, and when they are to be provided.

G. Note on Energy Estimating/Simulation Tools:

It is expected that mutually agreed upon, widely accepted, and validated computer-based estimating tools will be used, such as those software tools suggested in Section 4 of Reference Standard 29 of the Washington State Energy Code. Typically, more complex or demanding analysis will produce more precise analyses upon which to measure energy conservation measure and design strategy performance.

H. Read the IPMVP

At a minimum, project participants should read IPMVP Sections 3.0, 6.0, and Appendix II in order to become familiar with M&V concepts and approaches to implementing M&V.

M&V is analogous to building commissioning, but is intended to help preserve energy and water usage efficiency gains are over the long term. The IPMVP suggests parties enter into performance contracts, where the M&V contractor is paid based on the amount of energy and/or water saved, rather than typical fee-for-service contracts where a contractor's payments are not related to the performance of the installed systems. The IPMVP not only provides guidance on how to implement M&V, but it also provides guidance on establishing and carrying out contractual relationships related to M&V.

The latest version of the IPMVP and drafts of new section to be added may be downloaded from the following website: www.ipmvp.org

End of Appendix 1 - I